

## KINEMATICS AND KINETICS OF SQUAT AND DEADLIFT EXERCISES WITH VARYING STANCE WIDTHS

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The primary motion of squat and deadlift exercise involves flexion and extension of the hips, knees, and ankles, but each exercise can be performed with variations in stance width. These variations may result in differing kinematics and ground reaction forces (GRF), which may in turn affect joint loading.

**PURPOSE:** The purpose of this investigation was to compare ankle, knee, and hip kinematics and kinetics of normal squat (NS), wide-stance squat (WS), normal deadlift (ND), and sumo deadlift (SD). We hypothesized that hip joint kinematics and work at each joint would differ between exercise variations.

**METHODS:** Six subjects (3 m/3 f;  $70.0 \pm 13.7$  kg;  $168 \pm 9.9$  cm) performed each lift in normal gravity on the ground-based version of the Advanced Resistive Exercise Device (ARED) used on the International Space Station. The ARED provided resistance with a combination vacuum tube/flywheel mechanism designed to replicate the gravitational and inertial forces of free weights. Subjects completed each lift with their 10-repetition maximum load. Kinematic data were collected at 250 Hz by a 12-camera motion-capture system (Smart-D, BTS Bioengineering, Milan, Italy), and GRF data were collected at 1000 Hz with independent force platforms for each leg (Model 9261, Kistler Instruments AG, Winterthur, Switzerland). All data were captured simultaneously on a single workstation. The right leg of a single lift for each motion was analyzed. Modeling software (OpenSim 2.2.0, Simbios, Palo Alto, CA) determined joint kinematics and net positive and negative work at each lower extremity joint. Total work was found as the sum of work across all joints and was normalized by system mass. Effect sizes and their 95% confidence intervals were computed between conditions. **RESULTS:** Peak GRF were similar for each lift. There were no differences between conditions in hip flexion range of motion (ROM). For hip adduction ROM, there were no differences between the NS, WS, and SD. However, hip adduction ROM was greater during the NS and SD than during the ND. Hip rotation ROM was greater during the WS than during the NS and SD, and was greater during the SD than during the ND. For knee and ankle flexion ROM, the ND, WS, and SD were not different, but ROM was greater during the NS than the ND and greater during the WS than the SD. Total eccentric work was greater during the WS than the SD. Otherwise, there were no differences in eccentric or concentric work between conditions. **CONCLUSIONS:** Although squat and deadlift exercises consist of similar motions, there are kinematic differences between them that depend on stance width. Total eccentric and concentric work are similar for different lifts, but differing kinematics may require activation of different musculature for each variation. With respect to each condition, in the ND the ROM of each joint tended to be less, and the WS tended to trade knee motion for hip motion. **PRACTICAL APPLICATIONS:** Knowledge of differences in kinematics and kinetics between different squat and deadlift variations is important for coaches and rehabilitation personnel to understand when prescribing exercise. Our results suggest that each variation of the squat and deadlift should be considered a separate exercise that may induce different long-term training effects. **ACKNOWLEDGMENT:** This investigation was supported by the NASA JSC Human Research Program.